

Electrical Excitability Changes in Skeletal Muscle Compared to Nerve

Dr Doaa Abou-Bakr
Ass. Prof. of Physiology

By the end of this lecture the student will be able to:

- 1- Describe with illustration the skeletal muscle electric response (**action potential**).
- 2- Describe the skeletal muscle mechanical response (**simple muscle twitch**).
- 3- Explain the **excitability changes** of the skeletal muscle during action potential.
- 4- Define **motor unite**, **motor neuron pool** and motor unite **recruitment**.
- 5- Define **all or none-law** and identify which tissues that obey to that law and which not.

Skeletal Muscle Electric Response = Muscle Action :Potential

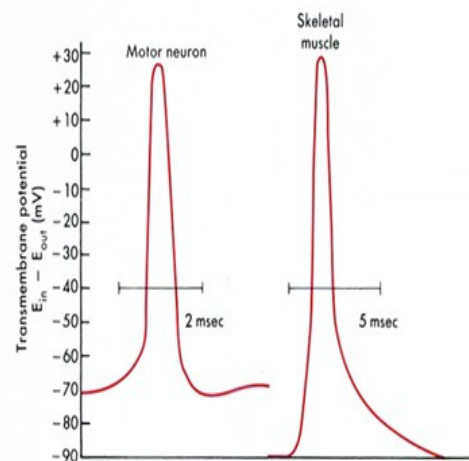
RMP in the muscle is about - 90 .1 mV (in the nerve - 70 mV)

The firing level is reached at .2 about - 40 mV (in the nerve - 55 mV)

The stimulation causes depolarization followed by **overshoot** .3 (reversal of polarity) which reaches up to about + 40 mV. (in the .nerve reach to about +35 mV)

Magnitude of spike potential is about 130 mV (from -90 to +40 .4 mV) [in the nerve it is 105 mV (-70 to +35)]

The **duration** of the action potential is about 2- 4 msec. (in the .5 nerve only 2 msec)



Skeletal Muscle Mechanical Response =Simple :Muscle Twitch (SMT)

Definition: It is one contraction followed by one relaxation of the muscle, produced by single maximum stimulation

:Composed of

- (1) Latent period.
- (2) Contraction period.
- (3) Relaxation period.

Latent period: It is the time passed between the application of a stimulus till the start of muscle contraction

:Causes

- .Conduction time in its nerve supply (1
- .Neuromuscular delay (2
- .Conduction of action potential along muscle membrane (3

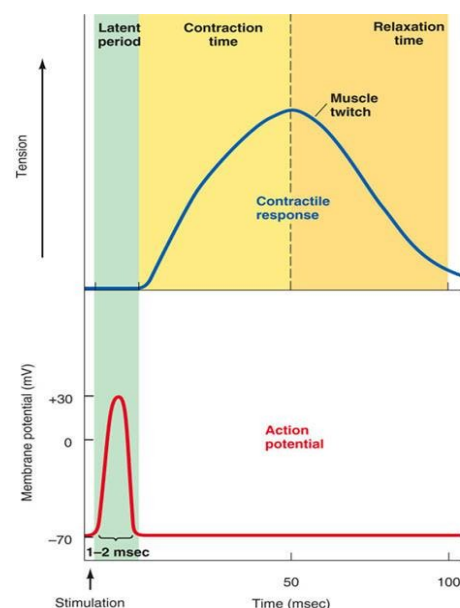
Contraction period: During this period, the muscle shortens, or its tension increased

Relaxation period: During this period, the muscle returns to its original length or the tension drops to the resting level

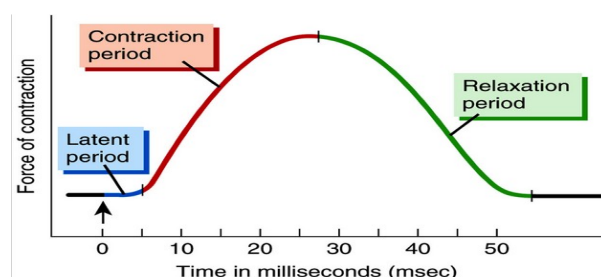
Excitability Changes of the Skeletal Muscle during its Electrical Response

the electrical response (action potential) and the mechanical response (SMT) are plotted simultaneously and on the same scale, it will be noticed that the mechanical response starts about 2 sec after the start of the action potential. i.e. **Electrical events precede (come before) mechanical events**

Absolute Refractory Period (ARP)



The duration of the action potential is not drawn to scale but is exaggerated.
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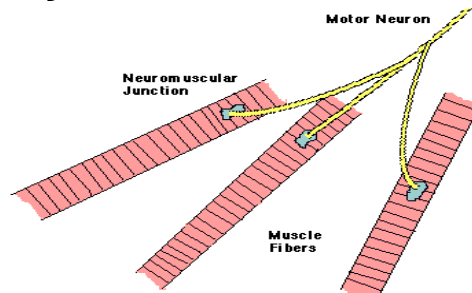
Electrically: occupies the ascending limb of depolarization + upper .1/3 of repolarization

Mechanically: occupies the latent period of the twitch

:Relative Refractory Period (RRP)

occupies lower .repolarization

occupies initial contraction .twitch



Electrically: 2/3 of

Mechanically: half of the phase of the

during the latent period of the twitch, the skeletal muscle is unexcitable (cannot respond to another stimulation). But during the contraction period of the twitch, the muscle can respond to another stimulation (i.e. summation of skeletal muscle contractions can occur)

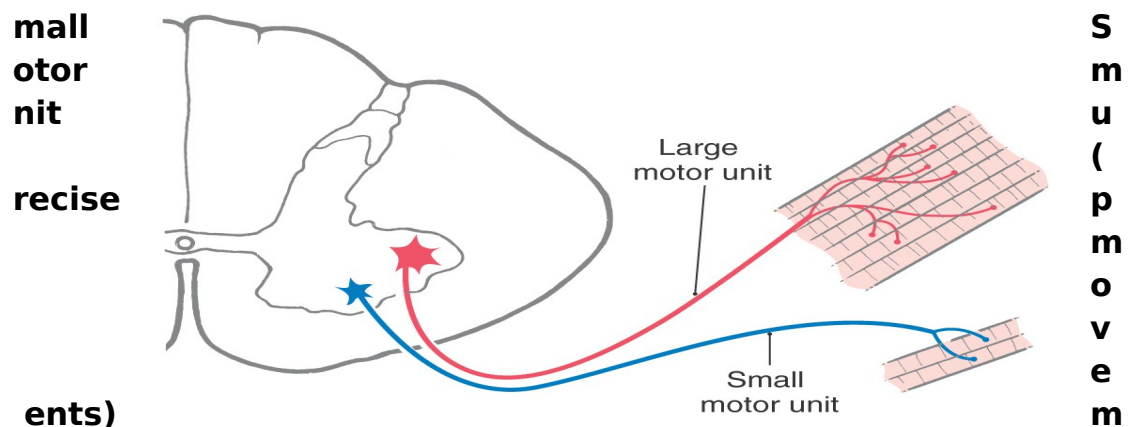
Therefore, -

Motor Unit

Definition: It is a motor neuron and all the muscle cells it .stimulates

:Motor unit size

.The number of muscle fibers in a motor unit varies



In muscles such as those of the hand, extra-ocular muscles i.e. muscles concerned with fine, graded and precise movements, there are 3 - 6 muscle fibers per motor unit = small motor unit

Large motor units (gross movements)

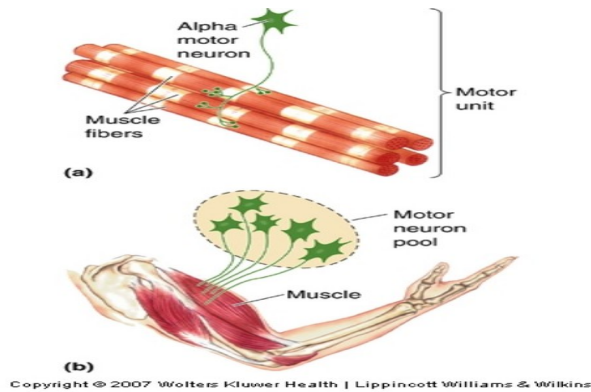
On the other hand, large muscles exhibiting gross movements, such as movements of the thigh, have large motor units in which a single neuron is connected to a large number of muscle cells e.g. in back muscles, there are 120 - 160 muscle fibers per motor unit = large motor unit

Motor Neuron Pool

Definition: It is the number of motor neurons that innervate the whole skeletal muscle

Unit ent

Motor Recruitm

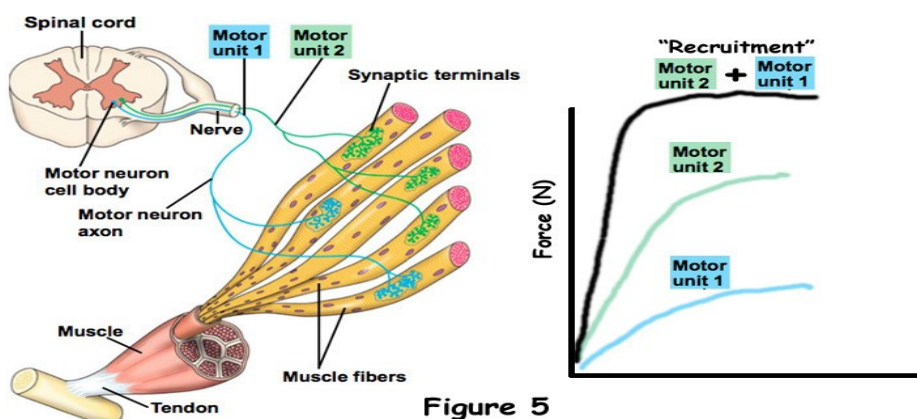


Increasing
.the number of motor unites activated

Definition:

When a strong contraction is needed, the nervous system may
.cause more than one motor unit to be stimulated

Stimulation of additional motor units for increased strength of
"contraction is called **"recruitment"**



ALL OR NON-LAW

If a single nerve fiber is stimulated with an inadequate (sub- - threshold) stimulus, no action potential is obtained, only a local non-
.propagated change in the membrane polarity

If a single nerve fiber is stimulated with an adequate (threshold) -
.stimulus, an action potential will result

If a single nerve fiber is stimulated with a supra-threshold stimulus, -
an action potential will result which has the same characteristic
amplitude, duration, and form regardless the strength of stimulus
i.e. supra-threshold stimulus will not increase the characteristics of
.action potential

.Sub-threshold stimulus → No action potential

.Threshold stimulus → Action potential

**Supra-threshold stimulus → Action potential with the same
.characteristics**

Action potential is an all or none event. It has fixed amplitude independent of the strength of the stimulus above the threshold value. Changes in the intensity of stimulation will increase the
.frequency of identical action potential (frequency-modulated)

➤ **The all or none law is obeyed in the following structures:**

.A single nerve fiber -

.A single skeletal muscle fiber and the motor unit -

The cardiac muscle and Visceral smooth muscles as they act as -
.one big unit (functional syncytium)

➤ **However, the nerve trunks, whole skeletal muscles and multi-unit smooth muscles do not obey this law; i.e. if the intensity of the stimulus is increased, the response will also increase.**